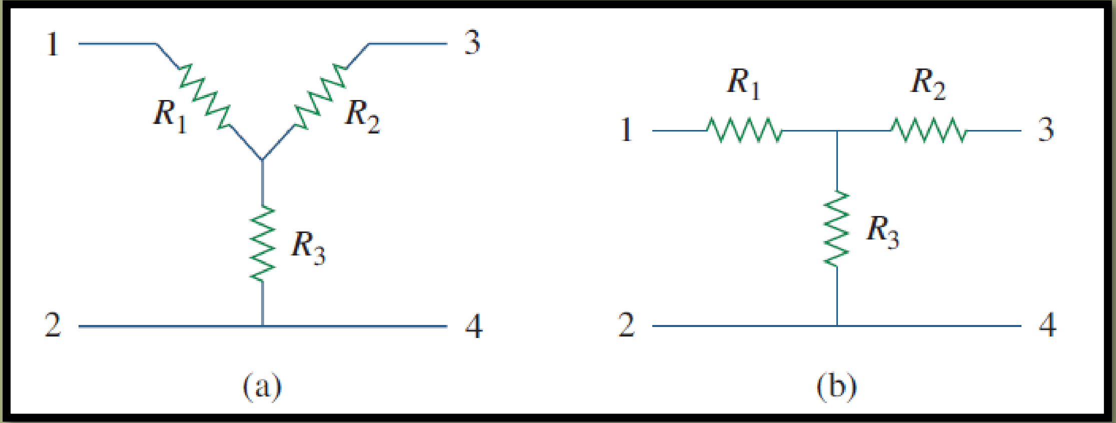
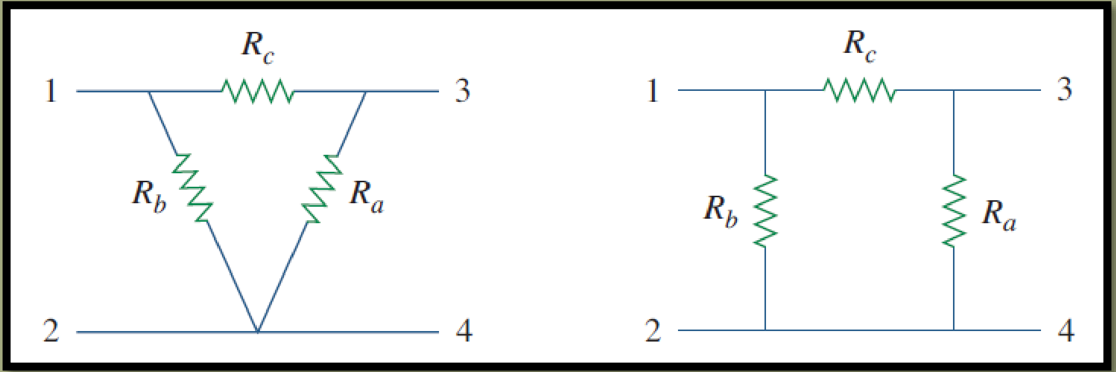
Circuit Analyses II

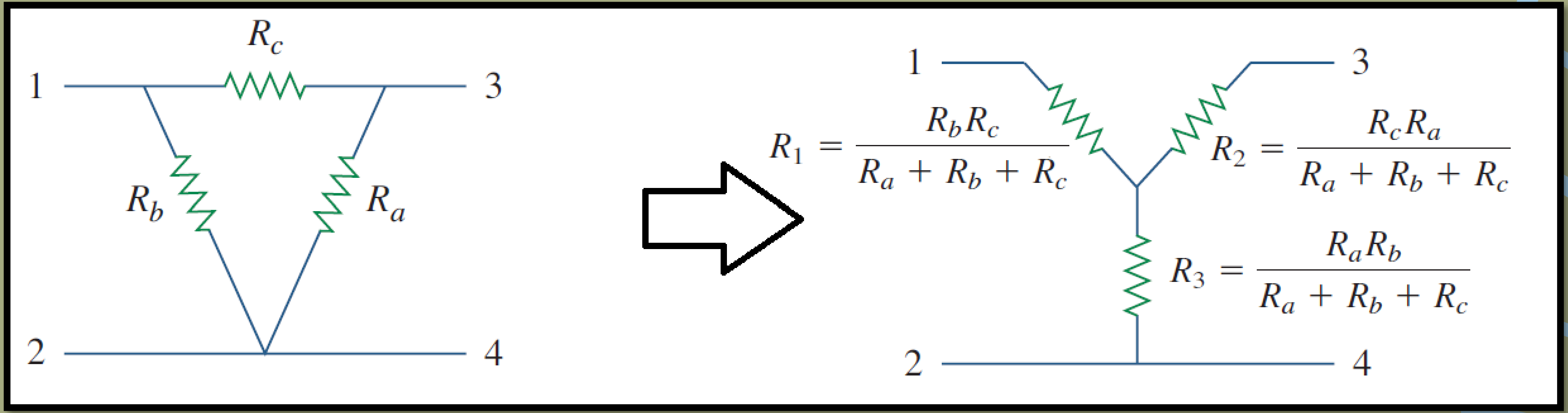
Dr. Mustafa M. Shiple

2.7 Wye-Delta Transformations

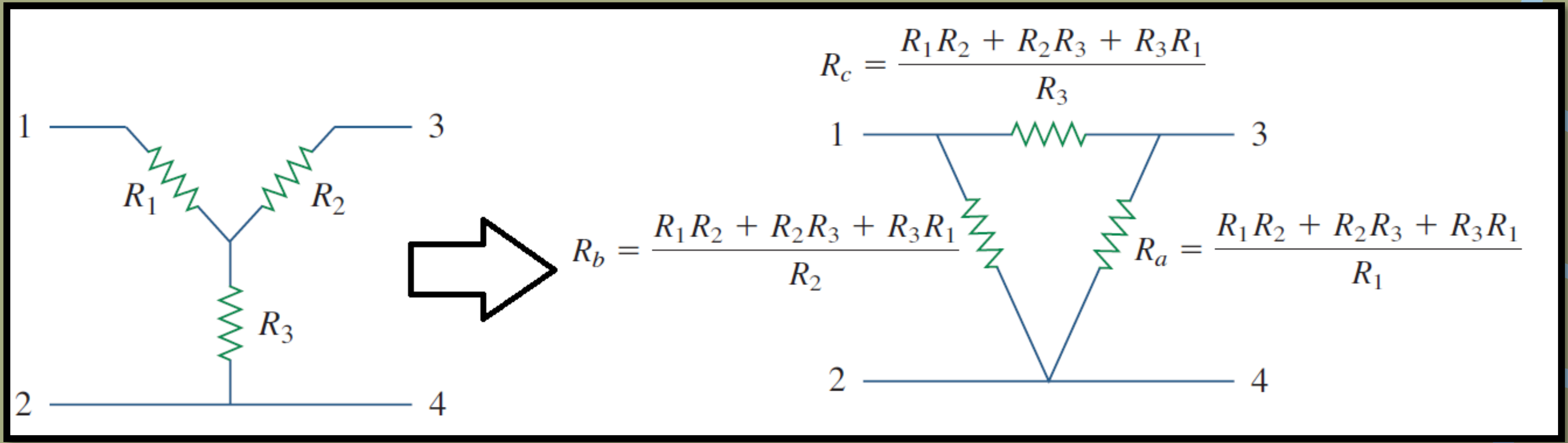




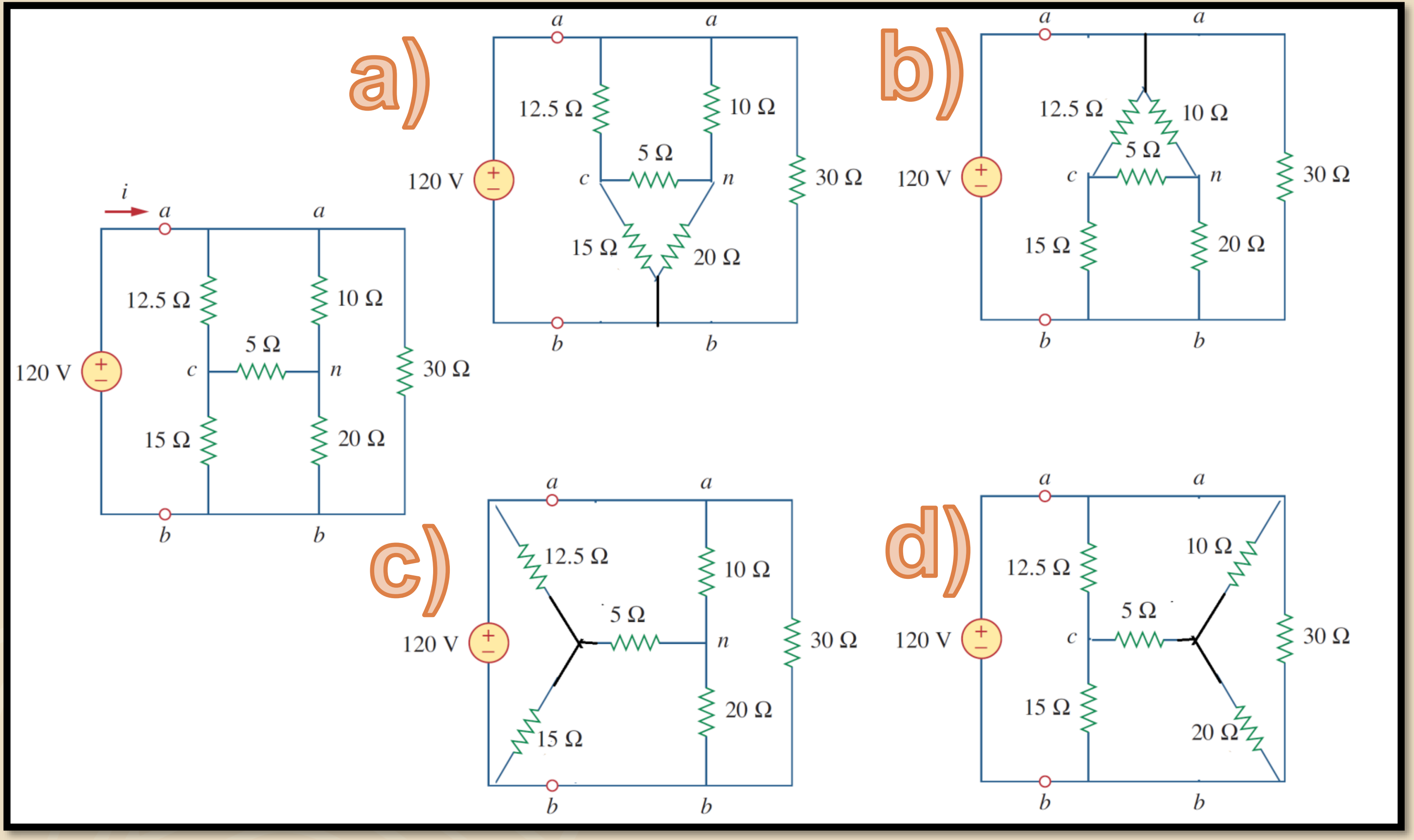
Delta to Wye Conversion



Wye to Delta Conversion

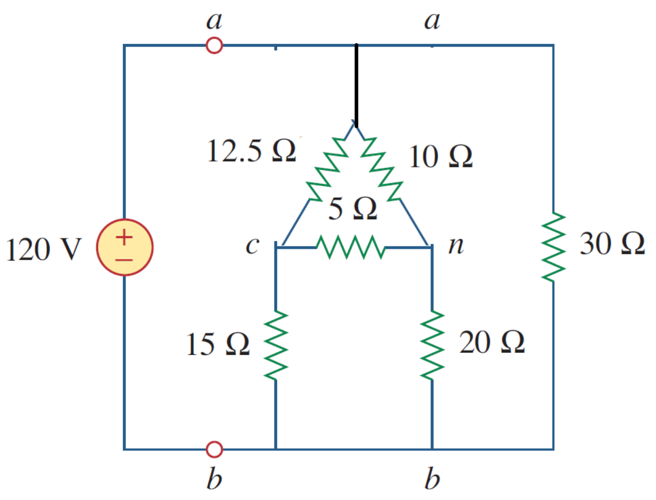


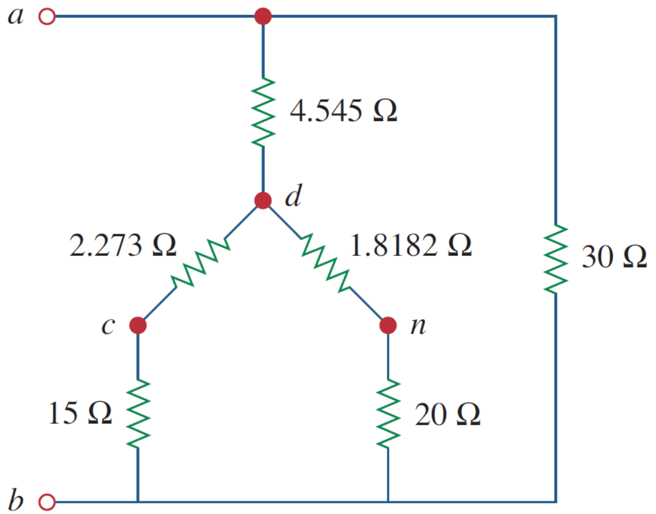
Exercise I



Exercise I

b)





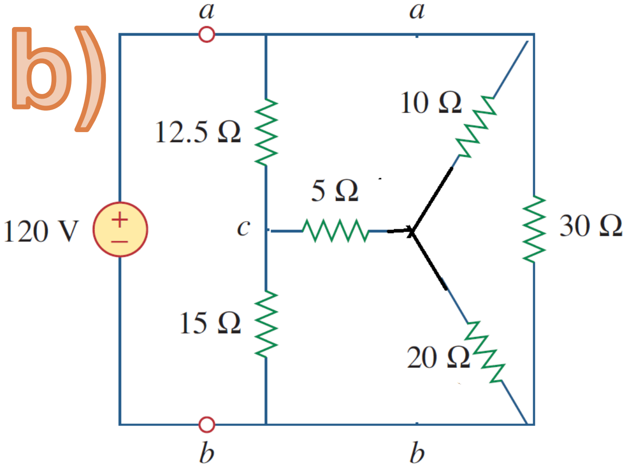
$$R_{ad} = \frac{R_c R_n}{R_a + R_c + R_n} = \frac{10 \times 12.5}{5 + 10 + 12.5} = 4.545\ \Omega$$

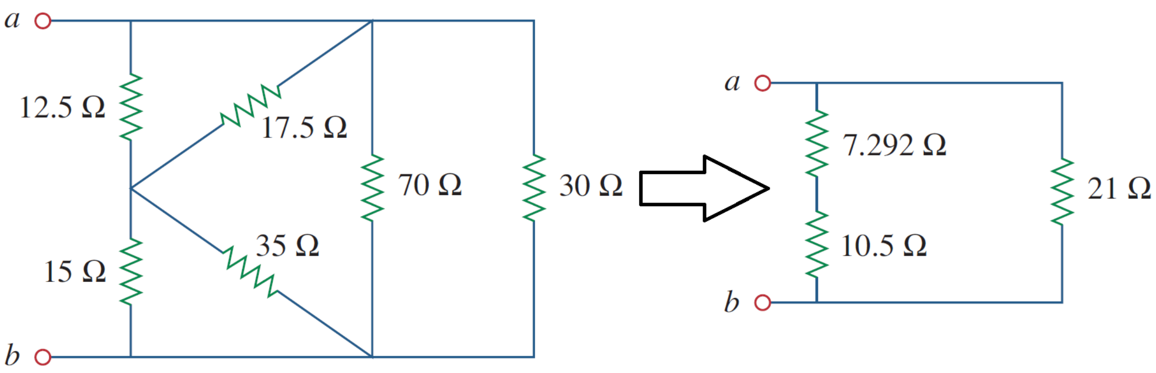
$$R_{cd} = \frac{R_a R_n}{27.5} = \frac{5 \times 12.5}{27.5} = 2.273\ \Omega$$

$$R_{nd} = \frac{R_a R_c}{27.5} = \frac{5 \times 10}{27.5} = 1.8182\ \Omega$$

Exercise I

b)





(a)

$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1} = \frac{10 \times 20 + 20 \times 5 + 5 \times 10}{10}$$

$$= \frac{350}{10} = 35\ \Omega$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2} = \frac{350}{20} = 17.5\ \Omega$$

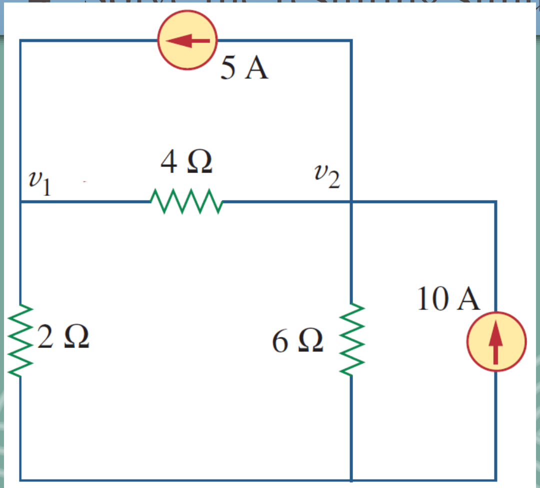
$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} = \frac{350}{5} = 70\ \Omega$$

3.2 Nodal Analysis

Nodal Analysis

Steps to Determine Node Voltages:

1. Select a node as the reference node.
2. Apply KCL to each of the nonreference nodes.
3. Use Ohm's law to express the branch currents in terms of node voltages.
4. Solve the resulting simultaneous equations.



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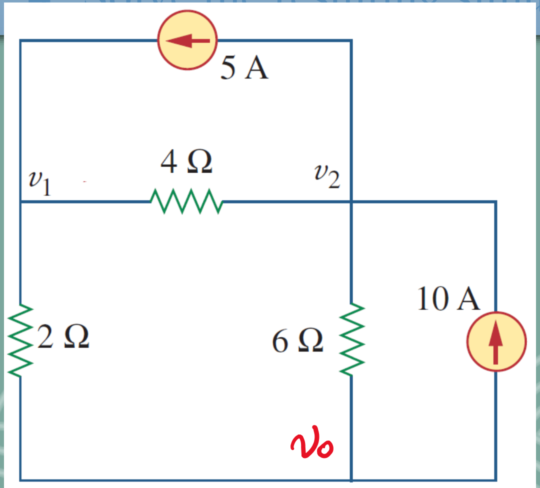

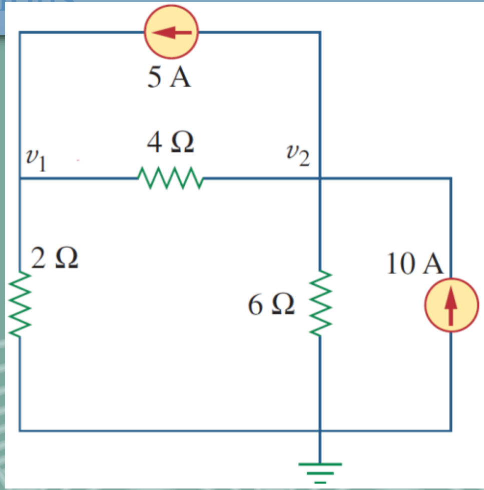

Nodal Analysis

Steps to Determine Node Voltages:

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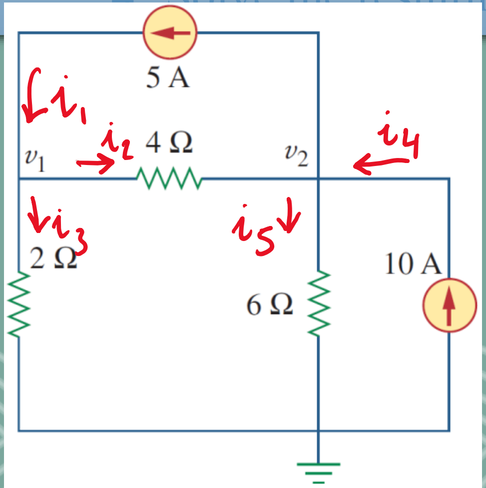

@ $v_1 \Rightarrow i_1 = i_2 + i_3 \longrightarrow$ (1)

@ $v_2 \Rightarrow i_2 + i_4 = i_5 + i_1 \longrightarrow$ (2)

Nodal Analysis

Steps to Determine Node Voltages:

1. Select a node as the reference node.
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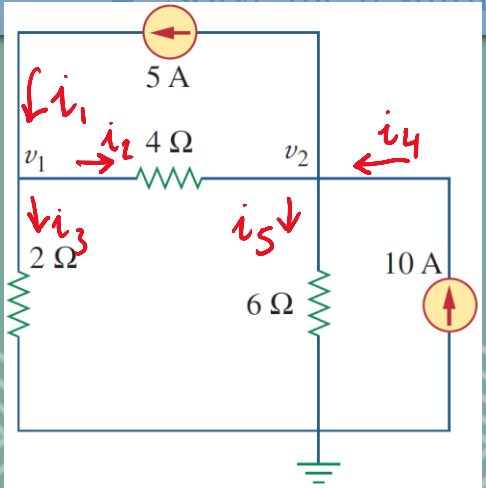


@ $v_1 \Rightarrow i_1 = i_2 + i_3 \longrightarrow (1)$

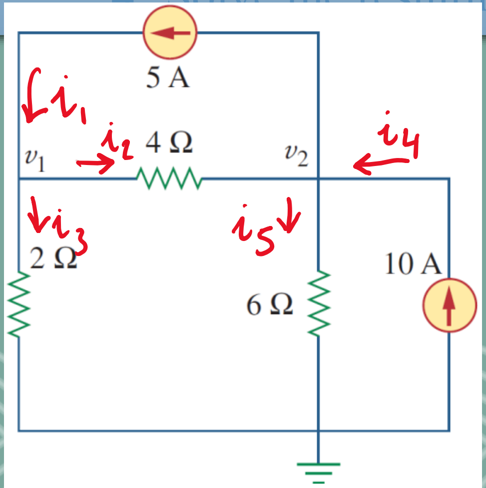
$5 = \frac{v_1 - v_2}{4} + \frac{v_1}{2} \Rightarrow 5 = \frac{3v_1 - v_2}{4}$

$\therefore\ 3v_1 - v_2 = 20 \longrightarrow (3)$

Nodal Analysis

Steps to Determine Node Voltages:

1. Select a node as the reference node.
2. Apply KCL to each of the nonreference nodes.
3. Use Ohm's law to express the branch currents in terms of node voltages.
4. Solve the resulting simultaneous equations.



@ $v_2 \Rightarrow i_2 + i_4 = i_5 + i_1 \longrightarrow$ (2)

$$\frac{v_1 - v_2}{4} + 10 = \frac{v_2}{6} + 5$$

$$\frac{v_1}{4} - \frac{v_2}{4} - \frac{v_2}{6} = -5 \Rightarrow \frac{v_1}{4} - \frac{10 v_2}{24} = -5$$

$$\Rightarrow v_1 - \frac{10}{6} v_2 = -20$$

Nodal Analysis

Steps to Determine Node Voltages:

1. Select a node as the reference node.
2. Apply KCL to each of the nonreference nodes.
3. Use Ohm's law to express the branch currents in terms of node voltages.
4. Solve the resulting simultaneous equations.

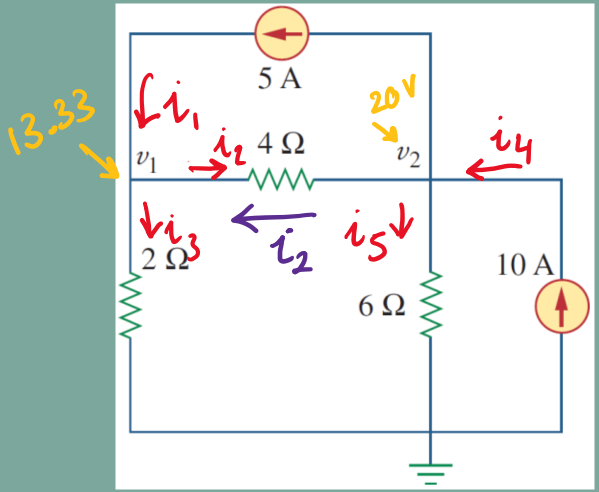
$3v_1 - v_2 = 20 \Rightarrow v_2 = 3v_1 - 20$

$v_1 - \frac{10}{6}v_2 = -20 \Rightarrow v_1 - \frac{10}{6}(3v_1 - 20) = -20$

$v_1 - 5v_1 + \frac{200}{6} = -20 \Rightarrow v_1 = 13.33V$

$\therefore v_2 = 20V$

Nodal Analysis



$$\therefore i_3 = \frac{13.33}{2} = 6.67\text{A}$$

$$i_5 = \frac{20}{6} = 3.33\text{A}$$

$$i_2 = \frac{13.33 - 20}{4} = -1.67\text{A}$$

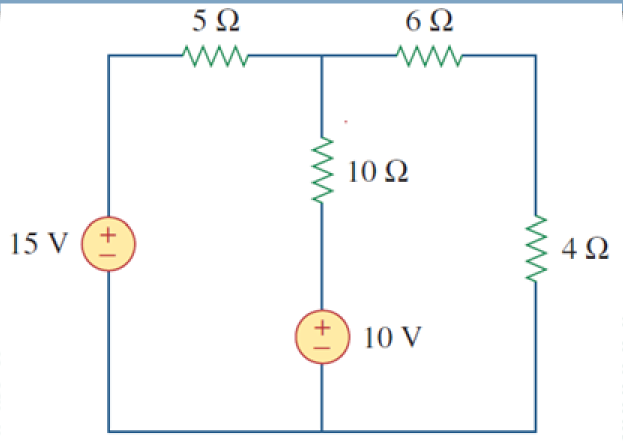
↖ wrong direction

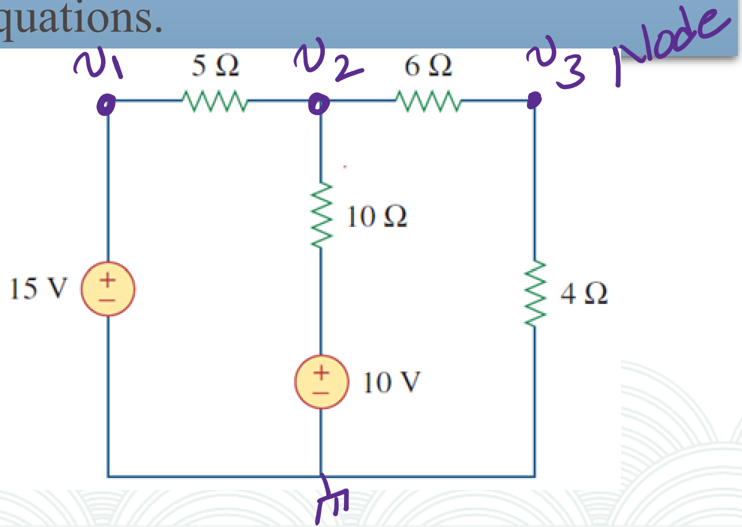
3.4 MESH Analysis

MESH Analysis

Steps to Determine Node Voltages:

1. Select mesh currents at each loop node.
2. Apply KVL to each of the nonreference nodes.
3. Use Ohm's law to express the branch currents in terms of mesh currents.
4. Solve the resulting simultaneous equations.

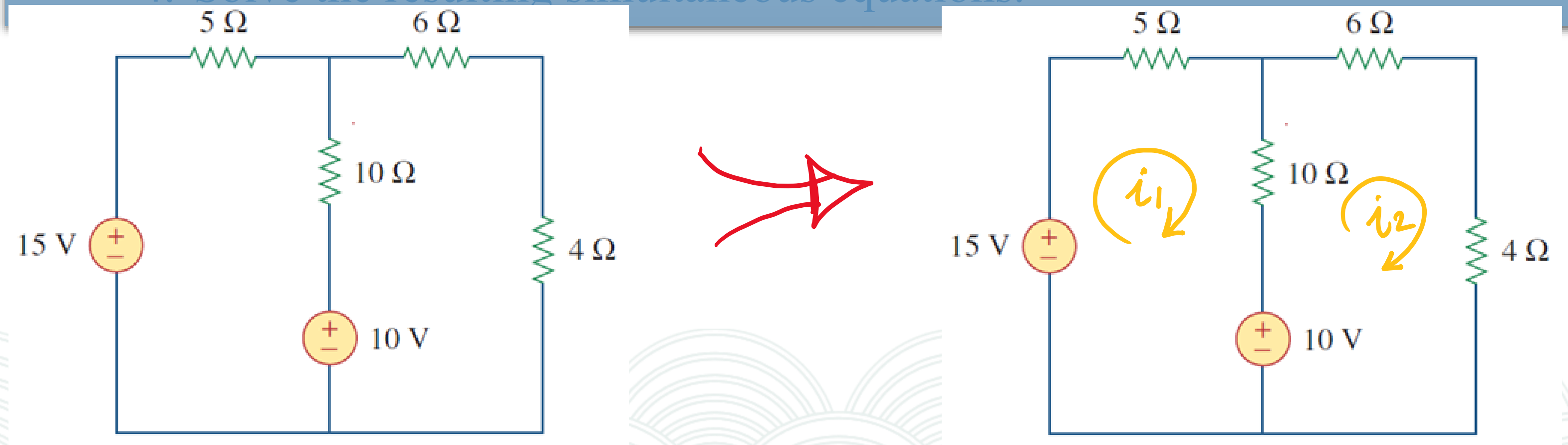




MESH Analysis

Steps to Determine Node Voltages:

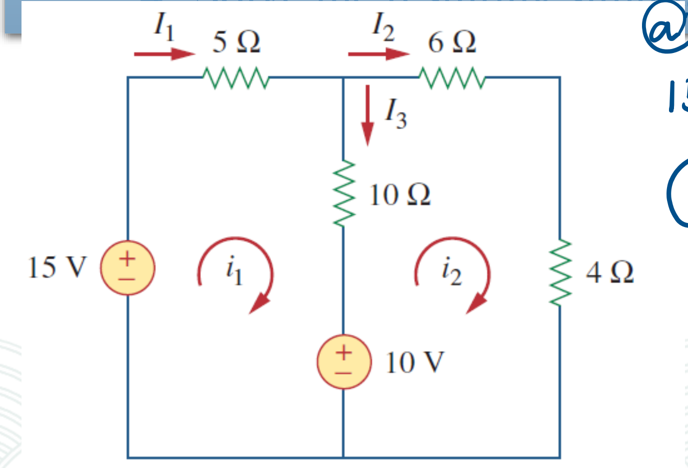
1. Select a node as the reference node.
2. Apply KVL to each of the nonreference nodes.
3. Use Ohm's law to express the branch currents in terms of mesh currents.
4. Solve the resulting simultaneous equations.



3.4 MESH Analysis

Steps to Determine Node Voltages:

1. Select a node as the reference node.
2. Apply KVL to each of the nonreference nodes.
3. Use Ohm's law to express the branch currents in terms of mesh currents.
4. Solve the resulting simultaneous equations.



@ loop i_1:

$$15v - 5I_1 - 10(I_1 - I_2) - 10 = 0$$

@ loop i_2:

$$10 - 10(I_1 - I_2) - (6+4)I_2 = 0$$

MESH Analysis

Steps to Determine Node Voltages:

1. Select a node as the reference node.
2. Apply KVL to each of the nonreference nodes.
3. Use Ohm's law to express the branch currents in terms of mesh currents.
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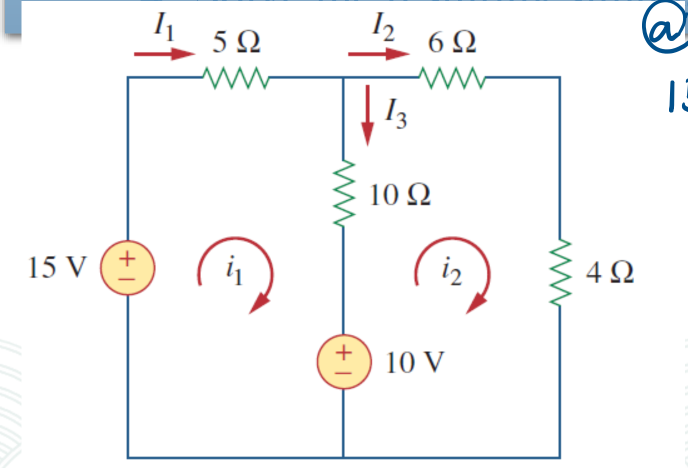


@ loop i_1:

$$15v - 5I_1 - 10(I_1 - I_2) - 10 = 0$$

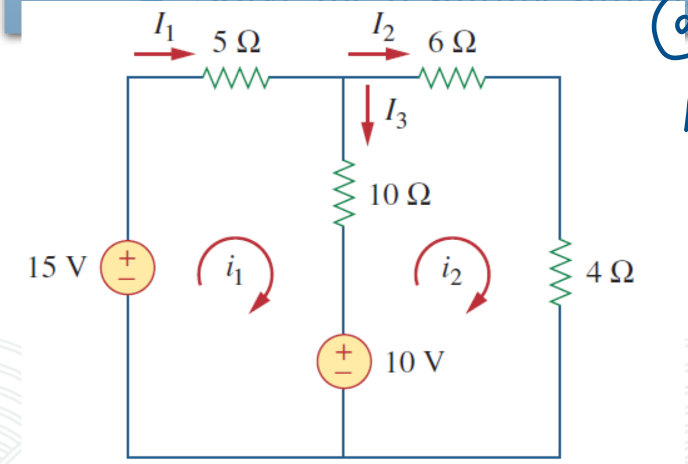
$$-15I_1 + 10I_2 = -5$$

$$I_2 = 1.5I_1 - 0.5 \longrightarrow (1)$$

MESH Analysis

Steps to Determine Node Voltages:

1. Select a node as the reference node.
2. Apply KVL to each of the nonreference nodes.
3. Use Ohm's law to express the branch currents in terms of mesh currents.
4. Solve the resulting simultaneous equations.



@ loop i_2:

$$10 - 10(I_1 - I_2) - (6+4) I_2 = 0$$

$$-10 I_1 = -10 \Rightarrow I_1 = 1\,A$$

$$\therefore I_2 = 1\,A$$

$$\therefore I_3 = I_1 - I_2 = 0\,A$$

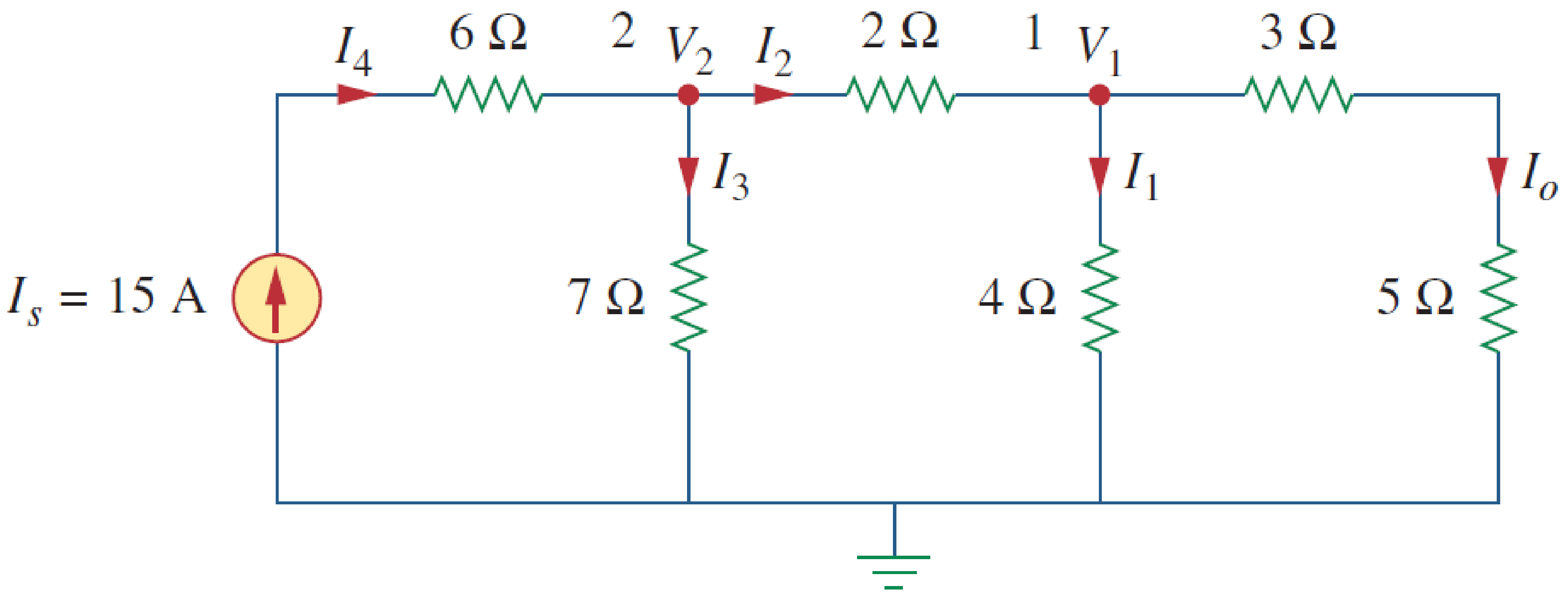
Thank you

Circuit Theorems

By : Dr. Mustafa M. Shiple

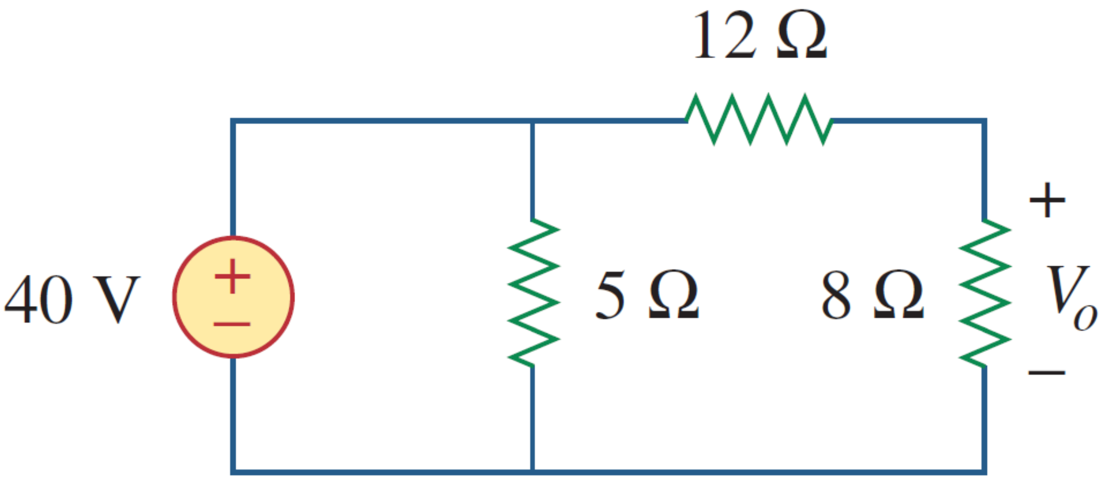
4.2 Linearity Property

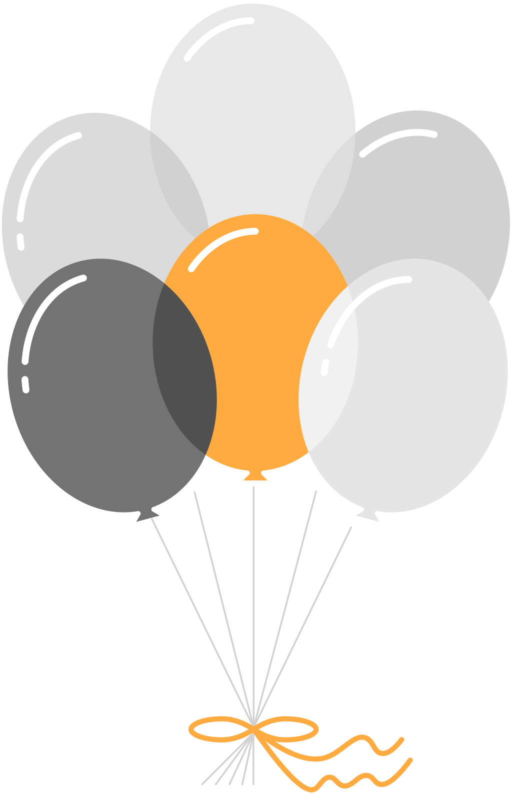
Assume $I_0 = 1\text{A}$ and use linearity to find the actual value of I_0 in the next circuit



4.2 Linearity Property

Assume $V_0 = 1\text{A}$ and use linearity to find the actual value of V_0 in the next circuit





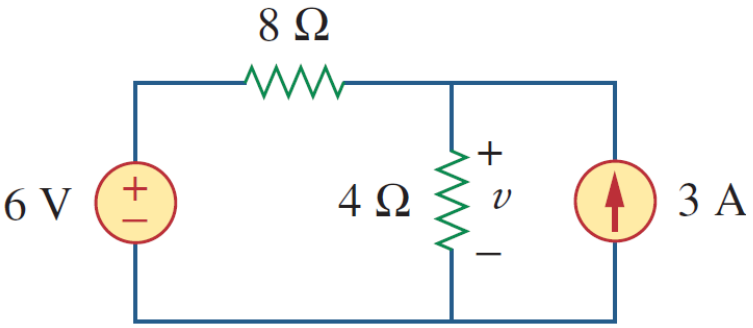
Superposition

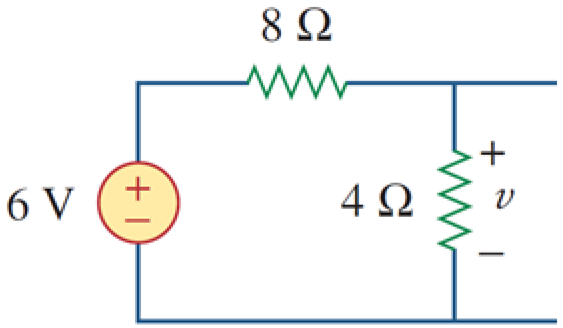
4.3 Superposition

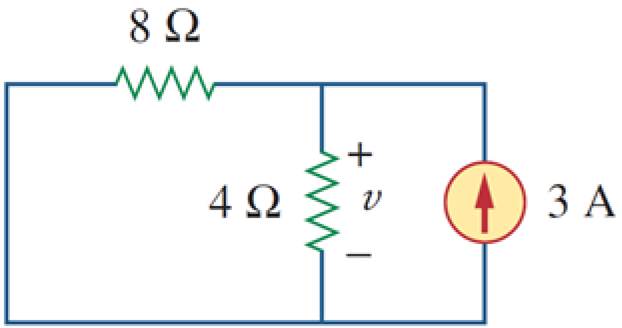
Steps to Apply Superposition Principle:

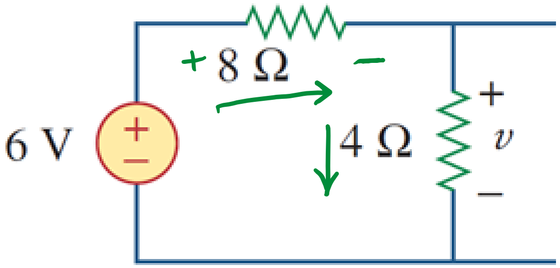
1. Turn off all independent sources except one source. Find the output (voltage or current) due to that active source .
    I. voltage source by 0 V (or a short circuit),.
    II. current source by 0 A (or an open circuit).
2. Repeat step 1 for each of the other independent sources.
3. Find the total contribution by adding algebraically all the contributions due to the independent sources.

4.3 Superposition





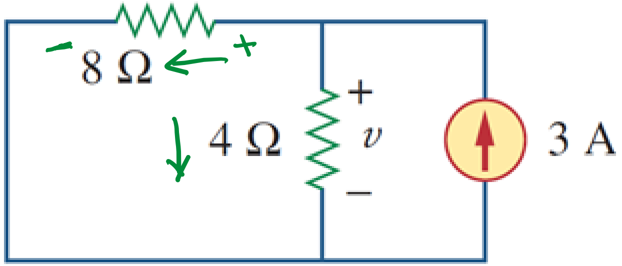




$$v_4 = v_s \frac{R_4}{R_4 + R_8} = 6 \frac{4}{12} = 2\,V \Rightarrow i_4 = 0.5A$$

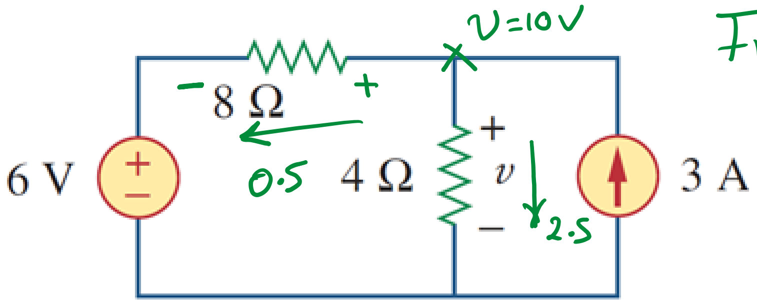
$$v_8 = v_s - v_4 = 6 - 2 = 4\,v \Rightarrow i_8 = 0.5\,A$$

$$i = \frac{6}{12} = 0.5\,A$$



$$i_8 = i_s \frac{R_4}{R_4 + R_8} = 3 \frac{4}{12} = 1\,A \Rightarrow v_8 = 8V$$

$$i_4 = i_s \frac{R_8}{R_4 + R_8} = 3 \frac{8}{12} = 2\,A \Rightarrow v_4 = 8V$$



Final Result

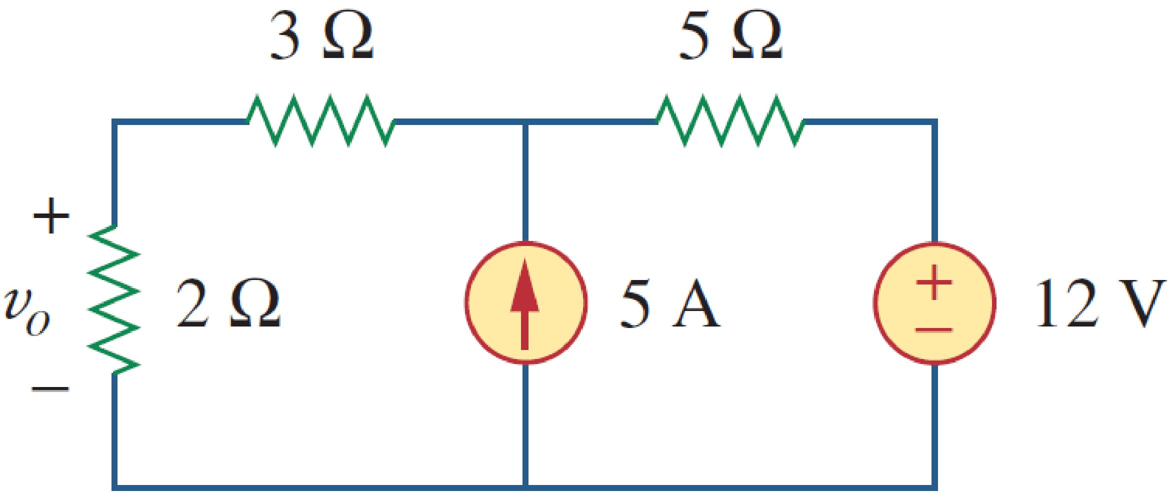
$$\therefore i_4 = 0.5 + 2 = 2.5\,A$$

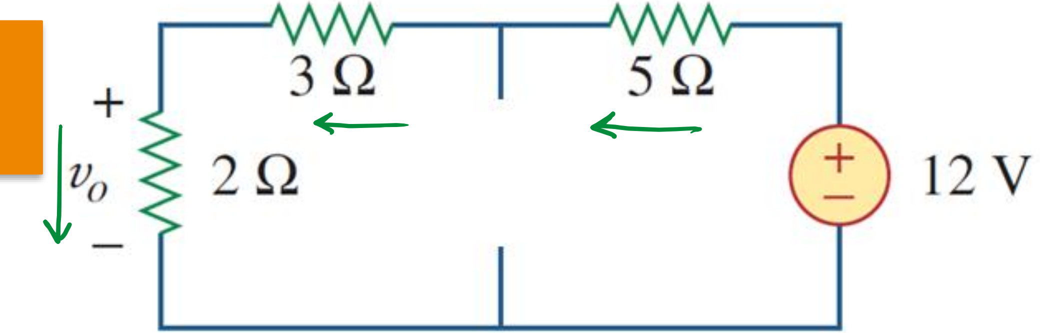
$$v_4 = 2 + 8 = 10\,V$$

$$i_8 = 0.5 - 1 = 0.5\,A$$

$$v_8 = 4 - 8 = 4\,V$$

Exercise



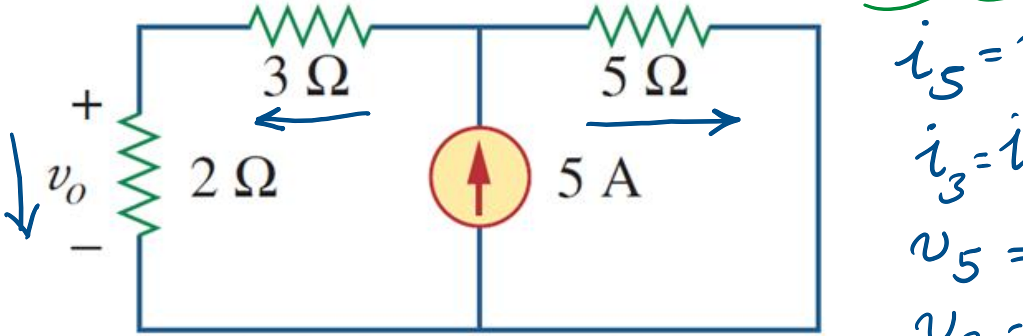


$$i = \frac{v_s}{\Sigma R} = \frac{12}{10} = 1.2A$$

$$v_5 = i * 5 = 6v$$

$$v_3 = 3.6V$$

$$v_o = 2.4V$$

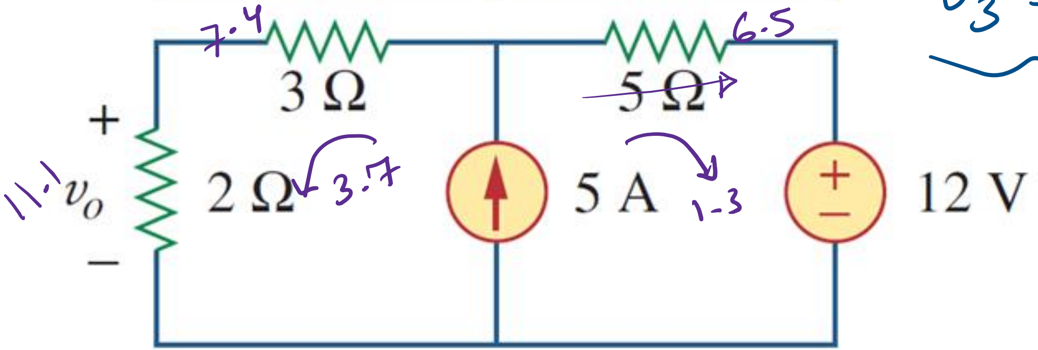


$$i_5 = i_s \frac{R_3 + R_2}{R_3 + R_2 + R_5} = 5 \frac{5}{10} = 2.5A$$

$$i_3 = i_2 = i_s \frac{R_5}{R_3 + R_2 + R_5} = 2.5A$$

$$v_5 = i_5 * 5\Omega = 12.5V$$

$v_3 = 7.5V$ & $v_o = 5V$



Final answer

$$\vec{i_5} = 1.2 - 2.5 = 1.3A$$

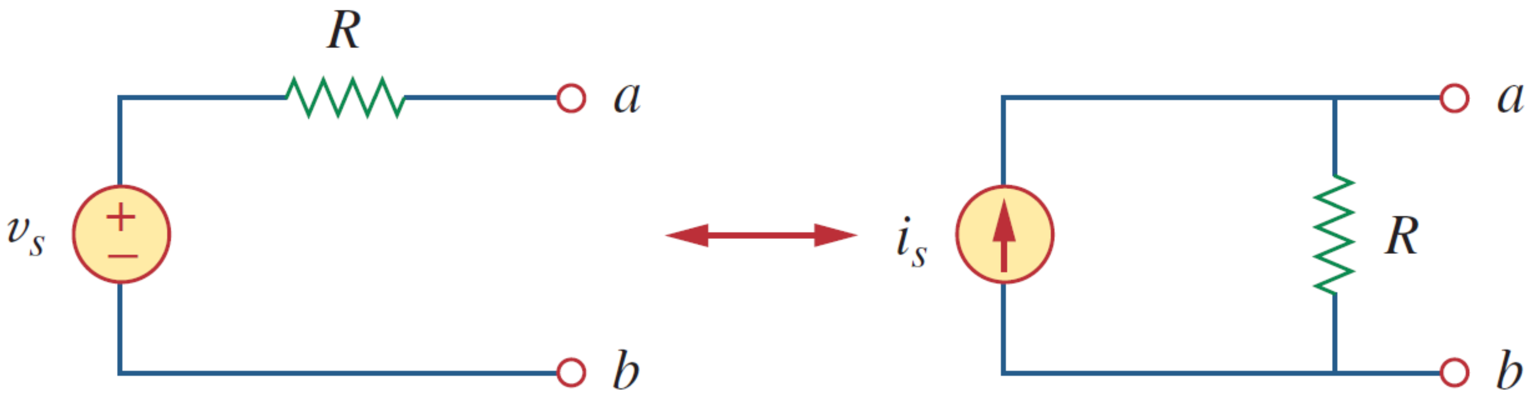
$$\vec{v_5} = 6 - 12.5 = 6.5V$$

$$\overleftarrow{i_3 = i_2} = 1.2 + 2.5 = 3.7A$$

$v_3 = 7.5 + 3.6 = 11.1V$ && $v_o = 7.4V$

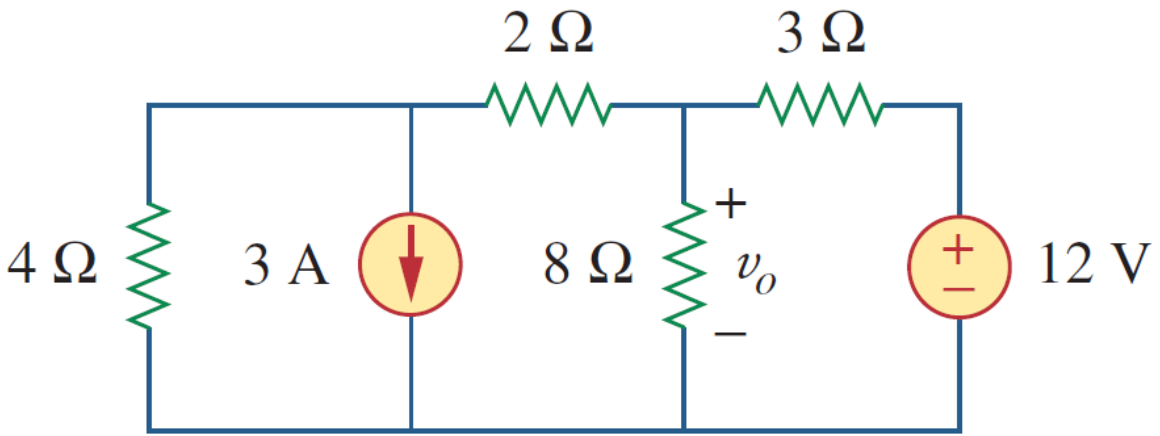
4.4 Source Transformation

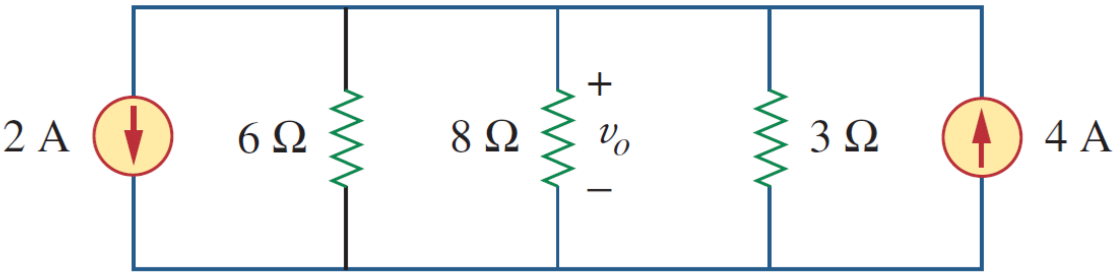
Independent Sources

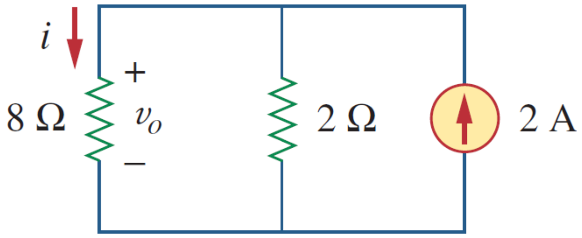


1. Arrow of the current source Is directed toward the positive terminal of the voltage source.
2. Source transformation is not possible when R=0.

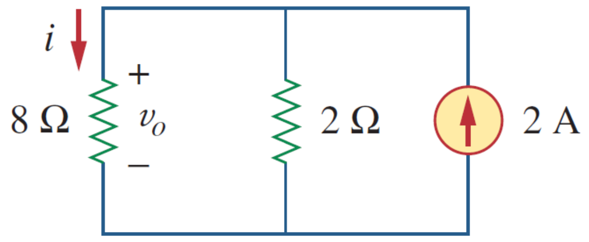
Exercise







Exercise



$$i = i_s \frac{2}{10} = 2 \frac{2}{10}$$

$$= 0.4A$$

$$v_o = i * R = 0.4 \times 8 = 3.2V$$


Any Questions